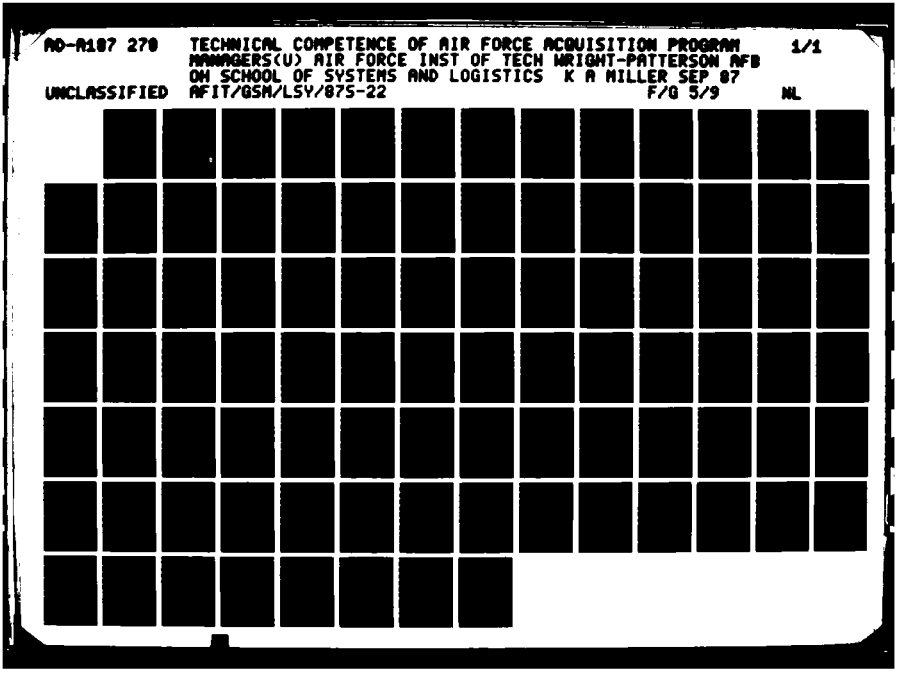
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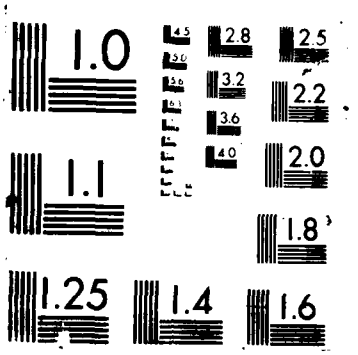
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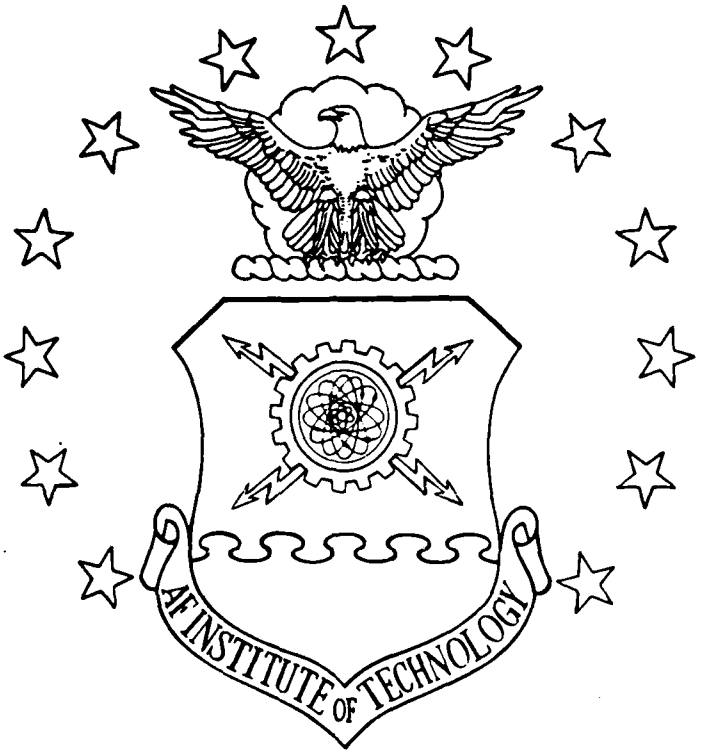




DEPARTMENT OF THE AIR FORCE

AIR UNIVERSITY

# AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

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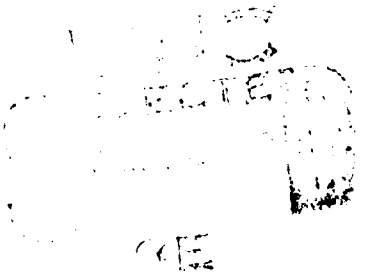
AFIT/GSM/LSY/87S-22

# TECHNICAL COMPETENCE OF AIR FORCE ACQUISITION PROGRAM MANAGERS

THESIS

Kurt A. Miller
Captain, USAF

AFIT/GSM/LSY/87S-22



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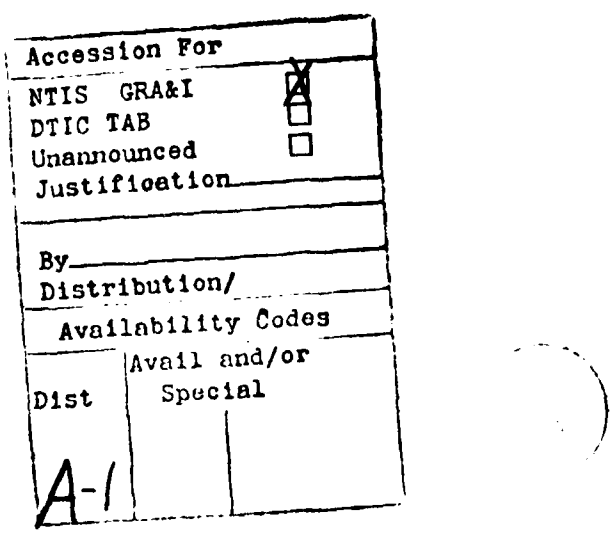

AFIT/GSM/LSY/87S-22

# TECHNICAL COMPETENCE OF AIR FORCE ACQUISITION PROGRAM MANAGERS

THESIS

Presented to the Faculty of the School of Systems and Logistics
of the Air Force Institute of Technology
Air University
In Partial Fulfillment of the
Requirements for the Degree of
Master of Science in Systems Management

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Captain, USAF

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## Preface

As an Air Force officer involved in managing the acquisition of modern weapon systems, I have always felt that my electrical engineering undergraduate degree was of definite benefit. My specialty in electromagnetic fields and waves helped me to feel comfortable in dealing with technical issues associated with radar and communications systems. At the same time, however, I have realized that much of the technical knowledge I have acquired was not gained from my academic education. I attribute my own technical expertise more to an intrinsic ability to assimilate information than to my academic background.

Being aware of the significant differences among various specialties within an electrical engineering degree program and the broader disparities between different types of engineering curricula, I am disturbed by those who classify individuals into just two groups--engineers and those who are not. I have known Air Force acquisition personnel with engineering degrees who, in my judgement, did not do well at absorbing technical information and applying it to their job. On the other hand, I have met a number of individuals without technical degrees who were able to deal very effectively with complex technical issues.

My personal view is that those directly involved in managing the acquisition of modern military systems need to thoroughly understand the technical aspects of the system being acquired in order to make the proper management decisions. A program office comprised of "non-technical" business managers assisted by an engineering support staff is suboptimal, in my opinion.

Holding this view, I was surprised to find that a proposed new regulation addressing career development and selection of Air Force acquisition managers barely mentioned technical considerations. I was further concerned upon discovering that, according to other officer personnel regulations, a prerequisite for becoming a Program Manager is based upon one's undergraduate education.

This study focused on technical competence of the Air Force System Program Office (SPO) director; the program management job I consider to be at the pinnacle of the acquisition management profession. It attempted to discover how technical competence in program managers is related to academic education and to intrinsic aptitude. It also attempted to identify cases where the importance of a high level of technical competence might be situation dependent and to identify technical areas which warrant increased training emphasis. This was largely an exploratory study which will hopefully be useful as a basis for ongoing research.

I would like to acknowledge two AFIT professors whose instruction was extremely beneficial in this endeavor--Dr. Charles Fenno and Professor Dan Reynolds. The professionalism and dedication of these gentlemen is simply exceptional. I would also like to thank my wife, Linda, for helping to keep the true priorities of life, my relationship with God and my family, in the proper perspective.

— Kurt A. Miller

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## Abstract

This study explored how perceived technical competence of Air Force acquisition program managers is related to academic education and intrinsic technical aptitude. Technical competence was defined as the program manager's ability to assimilate technical program information and effectively factor it into his decision making at a level commensurate with his position. This study also attempted to identify certain situational factors which might increase the importance of a program manager having a high level of technical competence and to identify technical areas which warrant increased training emphasis.

Data was collected through personal interviews with officers in Air Force Specialty Code (AFSC) 2996 Program Manager (System Program Director) positions and their technical advisors. Key findings were: (1) a strong positive correlation exists between intrinsic technical aptitude and perceived technical competence; (2) perceived technical competence of officers with electrical and aeronautical engineering degrees was significantly higher than that of officers with mathematics, business, or liberal arts degrees; (3) a significant proportion of the officers interviewed did not meet current mandatory educational prerequisites for entry into the AFSC 2996 specialty;

(4) officers in AFSC 2996 positions who function as single managers for developing and delivering a system (i.e., true SPO directors) consider technical competence to be a significantly more important job requirement than do other 2996's; (5) a majority of those interviewed feel technical ability should be a consideration in the new Acquisition Manager Career Development Program selection process; and (6) computer software development is an area which warrants increased emphasis in the training of future acquisition program managers.

Among the recommendations made were that the Air Force consider dividing the 29XX Program Manager utilization field into separate specialties (one for those heading system program offices and another for positions with broader oversight responsibilities) and that efforts be made to match individual program manager attributes with particular job needs in conjunction with or in addition to the new Acquisition Management Career Development Program certification and selection process.

# TECHNICAL COMPETENCE OF AIR FORCE ACQUISITION PROGRAM MANAGERS

## I. Research Problem

### Introduction

The System Program Office (SPO) director of an Air Force acquisition program holds a unique program management position (2:22). As the single manager (by regulation) for a program, the SPO director is generally delegated a significant amount of responsibility, authority, and accountability for attaining program objectives (3:3, 5-6). Successful program management requires the SPO director to possess a wide range of capabilities and attributes (7; 13).

Modern systems developed and acquired by the Air Force are typically associated with "high-technology." While there has been an emphasis on career development and selection policies for program managers recently, a review of the pertinent regulations indicates that the emphasis has been on management training, acquisition experience, and military education for a variety of acquisition management duties leaving an ambiguous policy as to the importance of program manager technical competence (7; 12; 16:42,54, 65-66).

This study attempted to clarify the importance of technical competence in Air Force program managers and to investigate the determinants of that competence. The objective was to identify areas where changes to acquisition management career development and selection policies might be warranted.

## Definitions

The meanings of key terms used throughout this report are as follows:

1. Program manager--an Air Force officer (lieutenant colonel or colonel) in a 2996 or 2991 Duty Air Force Specialty Code (DAFSC) position as defined in AFR 36-1. Program managers generally provide executive management supervision for major system acquisition programs.

2. SPO director--a program manager (defined above) who functions as the single manager for developing and delivering a system. The SPO director organizes and directs a system program office (SPO) and is the same as the Program Manager (PM) referred to in AFR 800-2 and the Packard Commission report (3:2,5; 16:54).

3. SPO director candidate--an Air Force officer (second lieutenant through major) covered by the Air Force Systems Command (AFSC) Acquisition Management Career Development Program (defined in AFSCR 36-5) who hopes to become a SPO director.

4. Technical--having to do with applied science, engineering, or technology.

5. Technical competence--the ability to assimilate and use technical information. As used herein, technical competence applies specifically to a program manager's ability to understand technical concepts at a level of detail commensurate with his management position and to properly factor that knowledge into his decision making. Technical competence is assumed to be a function of education, experience, and intrinsic attributes.

6. Technical aptitude--an intrinsic tendency to consider and employ technical information. A natural readiness to learn technical knowledge. Inquisitiveness and the propensity to ask technical questions is considered a factor of technical aptitude.

7. Technical undergraduate degree--a Bachelor of Science degree with specialization in engineering, engineering science, engineering management, physical science, or math. This is a mandatory prerequisite for becoming a program manager (7).

8. Technical advisor--the primary individual charged with advising a program manager on technical program issues (e.g., the Chief Systems Engineer).

9. Program phase--a stage of development or fielding of a system acquired by the Air Force. Concept Definition, Demonstration and Validation, Full-scale Development,

Production and Deployment, and Operations Support were the phases considered in this study. Acquisition program managers may be involved in any of these phases, but responsibility for management of a system often is transferred from the Air Force Systems Command SPO director to an Air Force Logistics Command System Manager during the Production and Deployment phase.

General Issue

Air Force policy concerning the importance of program manager technical competence appears to be ambiguous. On one hand, technical competence would seem to be an important element of effective Air Force program management since, by regulation, an Air Force officer must have a technical undergraduate degree in order to enter the program manager 2996 specialty (7). On the other hand, it does not appear that a serious concern actually exists for developing and certifying technical competence in program managers since the Air Force Systems Command (AFSC) Acquisition Management Career Development Program has no specific technology-oriented requirements in its certification process and does not include technical competence in its "best qualified" criteria used to select officers eligible for senior program management positions (12).

The technical undergraduate degree requirement seems to be reasonable on the surface because a SPO director

must be able to orchestrate tradeoffs between technical options, schedule, and cost (3:3-6; 7; 19:234; 20:36). Technical competence may be important in effectively managing technical support staff and in discussing technical issues with superiors and other organizations (9:22-23). However, as currently delineated in the existing policies, the technical undergraduate degree is, in effect, a "square" to be filled on the way to becoming a program manager. Those with the appropriate type of degree are apparently deemed to be sufficiently "technically qualified." No further evaluation of technical abilities is officially involved.

The issue at hand is whether or not these policies are reasonable given the current emphasis on grooming and selecting the highest quality acquisition managers possible (12; 16:65-66).

## Specific Issues

Within the general issue described above are a number of issues which this study addressed specifically.

Benefits of a Technical Degree. A key issue investigated in this study was the link between academic educational background and perceived technical competence in program managers. In defining the qualifications necessary to become a program manager, AFR 36-1 states that

> . . . undergraduate academic specialization in engineering, engineering science, engineering management, physical science, or math is mandatory for entry into the specialty [7].

The Acquisition Management Career Development Program requires a "Master's Degree (or higher) in a technical or management field appropriate to program management" for "Level III" or "Level IV" certification which would apply to program managers (12).

If the purpose of a technical academic education is to provide an individual with specific technical knowledge to be used in performing SPO director duties, these requirements seem almost too broad. One might ask whether a math major has a satisfactory understanding of electronics principles to manage effectively in a service hungry for electrical engineers (15). Contrarily, given the wide range of technical issues the SPO director of a highly technical program is likely to encounter and the narrow focus of specialties within technical degrees (e.g., optics, electromagnetic fields/waves, and digital processing are separable specialties within an electrical engineering degree program), it seems unreasonable to expect academic education to provide specific background knowledge in all areas likely to be encountered, particularly in light of the rate at which technology is advancing. Nevertheless, the ever-increasing reliance on electronics and computers in modern systems might serve to justify a move toward

more stringent academic qualifications such as requiring some level of SPO director technical competence in these particular areas.

The rationale behind requiring the stated range of acceptable academic specialties might be the belief that all of the specialties foster a desired way of thinking (e.g., quantitative problem solving) and cover some desirable set of core areas such as calculus and basic computer programming which provide the necessary background education. Along with this is the notion that these undergraduate programs provide a "quality control" function. An individual must be somewhat intelligent and capable in order to obtain a degree in those specialties.

Not everyone would agree that a technical degree is desirable for program managers, however. Some work has been done to show that a nontechnical, "generalist" background is preferred for senior military managers (18).

A basic assumption of this portion of the study was that if a technical academic education is of benefit to a program manager, that benefit would be manifested in an increased ability to assimilate and use technical information and to factor that knowledge into decision making (i.e., increased technical competence). The issue addressed in this study was whether or not the type of undergraduate or graduate degree held by a program manager could be

shown to be associated with his or her ability to deal appropriately with technical program issues.

It should be noted that, since this was ex post facto research versus an experiment, if a relationship was shown to exist between type of academic education and technical competence, it would not necessarily imply causality.

The Role of Intrinsic Technical Aptitude. The second issue this study dealt with, taken as somewhat of a converse to the first issue discussed above, was the relationship between intrinsic technical aptitude and technical competence. Aptitude is defined by Webster as:

> 1. Readiness for learning; aptness.
> 2. General fitness or suitability; appropriateness.
> 3. Natural disposition or tendency to a particular action or effect.
> 4. Natural or acquired capacity or ability.
> 5. Potential as distinguished for developed ability; capacity for learning a certain performance or kind of work [22:135].

The third and fifth definitions come closest to the construct considered here. A program manager's natural tendency to personally engage technical issues, measured in this study by propensity to ask questions on technical aspects of the program, was part of the technical aptitude construct. The second part of the construct was potential for understanding newly presented technical information, which was indicated by quickness in learning new (not previously familiar) technical information.

The type of undergraduate or graduate degree an individual holds may not necessarily be a valid indication of his abilities or inclinations (8). Assuming that a program manager must deal with a wide variety of technical issues and that much of the technical information he gains is from other than formal academic education, technical aptitude could conceivably play a greater role in attaining a high degree of technical competence than formal training or education. At issue here was whether intrinsic technical aptitude, aside from formal education or experience, is significantly and positively related to technical competence.

Program Phase as a Moderator. Perhaps the characteristics associated with different programs call for different technical competency levels in the program managers who manage them. Conceivably a number of program-related moderating variables could exist which would correspond not only with the level of technical competence appopriate for managing a particular program, but to specific technical specialty areas as well. For example, a high level of program manager technical competence may be of greater importance on programs involving very advanced technology (2:36). Other research has indicated that the intensity of management conflicts associated with technical issues varies significantly during different phases of a program's

life cycle (20). This study explored the notion that program manager technical competence may be a more important factor when systems are in certain program phases.

Relative Importance of Technical Competence. SPO directors need an extremely broad range of skills, knowledge, and experience (12; 13). The importance of technical competence relative to other factors such as management ability, leadership, and operational experience is a logical concern. Would a lack of technical competence on the part of a program manager actually be detrimental to a program or is a high level of technical competence simply a "nice to have" attribute? Do program managers believe that technical competence is important enough, relative to other criteria, to be a consideration in selecting future program managers?

## Research Questions

The following research questions are based on the issues discussed above and are formulated for statistical analysis.

Research Question 1. Is program manager technical competence associated with type of academic educational background?

Research Question 2. Is program manager technical competence related to intrinsic technical aptitude?

Research Question 3. Does the perceived importance of a high level of program manager technical competence depend upon the acquisition phase of the program being managed?

Research Question 4. According to program managers, should technical competence be included in the criteria used to select "best qualified" officers eligible to fill key middle management and senior program management positions under the new Acquisition Management Career Development Program?

## Variables and Relationships

The following variables and relationships apply to the research questions. Operationalization and measurement of each variable is described in detail in Chapter III.

Research Question 1. This question concerned the relationship between type of academic educational degree and perceived program manager technical competence. One independent and one dependent variable were involved. The independent variable was the program manager's academic educational background which was treated as a categorical (nominal) variable. Specific types of academic degrees were placed into four different categories based on how

closely courses in the various curricula were believed to apply directly to current technical issues likely to be encountered by program managers. The categories were:

1. Electrical, computer, and aerospace engineering.

2. Other engineering, physical sciences, math and computer science.

3. Business/management, and other B.S./M.S. degrees not included in the above categories.

4. All other nontechnical (e.g., B.A.) degrees.

The dependent variable (interval level) was the perceived level of program manager technical competence which was measured using a subset of items from the Wagner and Morse sense of competence instrument (21). Five items from this instrument were tailored to apply specifically to technical competence and used to compute a composite variable which constituted the dependent variable. The items used addressed the following:

1. How well the program manager's level of technical competence met expectations for doing his job.

2. How well the technical competence exhibited by the program manager might serve as a model for an apprentice.

3. To what degree the program manager's talents lay in areas other than in dealing with technical aspects of programs he supervised.

4. How well the program manager familiarized himself with technical program issues considering the amount of time in the job.

5. To what degree the program manager had all of the technical skills necessary to perform well in his job.

Research Question 2. This question addressed the relationship between technical aptitude and technical competence. It involved the relationship between two variables. The independent variable (interval level) was perceived program manager technical aptitude. For the purpose of this study, the construct of technical aptitude included the following characteristics:

1. Program manager inquisitiveness on technical program aspects.

2. Program manager quickness in assimilating new technical information.

The dependent variable (interval), program manager technical competence, was the same as for Research Question 1 above.

Research Question 3. This question addressed the relationship between the importance of program manager technical competence and the program phase of the system being acquired. It involved the relationship between two variables. The independent variable was program phase

category (a nominal variable). The following categories were used:

1. Concept definition
2. Demonstration and Validation
3. Full-scale Development
4. Production and Deployment
5. Operations Support

Values of the program phase variable were based on the acquisition phase program managers indicated their programs were in at the time of data collection. In cases where a system was in more than one program phase (e.g., F-16 aircraft are operational, in production, and undergoing continued development), program phase was considered that which the program manager felt posed the most important technical issues.

The dependent variable (interval) was the perceived importance of the program manager having a high level of technical competence to perform well in his particular job. Two survey items were used to measure this construct. One item asked how important a consideration technical competence should be in selecting a hypothetical replacement for the program manager. The other, a reverse scored item, asked whether a lack of technical competence on the part of a new program manager could be a serious detriment to the program.

Research Question 4. This question addressed whether technical competence is important enough to be a separate criterion (at the same level as duty performance, leadership ability, and operational experience) in selecting Air Force officers for high level acquisition management positions. It involved a single variable, opinion as to whether or not technical competence was sufficiently important, which was treated as a Bernoulli variable (yes or no).

## Criteria for Data Source

The data source for this study was comprised of two groups: individuals filling Air Force Specialty Code (AFSC) 2996 Program Manager (Systems Program Director) positions (termed program managers in this study) and their technical advisors. Rather than using all officers who themselves hold or had held primary, secondary, or tertiary 2996 AFSCs as the population, those actually filling 2996 positions were used in an effort to tie the data collected directly to duties being performed. This allowed for data to be collected from some individuals without technical undergraduate degrees, and therefore not meeting all 2996 requirements, yet who were filling program manager positions.

The technical advisors included in the data source were those whom program managers indicated were primary in advising them on technical program issues. The reason for

obtaining opinion data from both program managers and their technical advisors was to provide a check for convergent validity on the ratings of program manager technical competence and technical aptitude.

Research Approach

The approach taken in this research effort was to conduct personal interviews with program managers and their technical advisors. The data collected during these interviews included such things as program manager educational background, program phase, and ratings of program manager technical competence and technical aptitude.

Because the question of whether program managers must be "engineers" is potentially subject to personal biases and is apparently an open issue (13:24) and because there is perhaps a natural tendency for a person to rate himself "very competent" in any job-related dimension, several things were done in the approach taken on this study. First, the interview survey instrument was carefully constructed to measure specific job-related perceptions and behaviors rather than simply asking broad questions of opinion like "Do you think a program manager's educational degree makes a difference?" Second, use of personal interviews rather than mail surveys helped to ensure that respondents fully understood the questions asked and the terms used. Third, ratings by technical

advisors of key items in the survey instrument enabled determination of the degree of convergent validity obtained.

## II. Background

Based on information gleaned from primary and secondary sources, this section provides background on Air Force program manager responsibilities and technical qualifications, why technical competence may be an important consideration, and measurement of technical competence.

### Air Force Acquisition Managers

The Air Force classifies the types of duty officers perform according to "utilization fields" and "specialties." Each type of job is assigned a four-digit Air Force Specialty Code (AFSC). The first two digits of an AFSC define a utilization field. Addition of the third digit defines a specialty. The fourth digit corresponds to the highest grade an officer in a particular specialty may hold. Air Force Regulation (AFR) 36-1 describes the officer specialty classification system and provides attachments which summarize the duties, responsibilities, and qualifications pertaining to each specialty.

A number of different utilization fields, such as Scientific (26XX), Development Engineering (28XX), and Logistics Plans and Programs (66XX) to name a few, are associated with acquisition management. The term

acquisition manager generally applies to officers in the Acquisition Program Management (27XX) and Program Management (29XX) utilization fields (12:1). The three officer specialties within these utilization fields are:

1. AFSC 2724 Acquisition Project Officer
2. AFSC 2716 Acquisition Management Officer
3. AFSC 2996 Program Manager (Systems Program Director)

Officers in AFSC 2724 positions may range in grade from second lieutenant through major. They "assist in planning and managing system, subsystem, or equipment acquisition programs" and often work for program managers in system program offices (SPOs) (6).

Officers in AFSC 2716 positions are the next level in terms of rank and responsibility. An Acquisition Management Officer "performs as Program Manager (PM) for the acquisition of any program not meeting the definition of a major program." The grade spread for 2716's is major through colonel. Those in AFSC 2716 positions generally do not head SPOs (5).

AFSC 2996 positions are filled by lieutenant colonels or colonels. The 2996 program manager "directs and provides executive management supervision for major acquisition programs." SPOs are generally headed by officers in AFSC 2996 positions (7).

This study focused on officers in 2996 positions and, as used herein, the term "program manager" refers to these officers. The term "SPO director," as used in this report, refers to the subset of program managers who head SPOs and direct acquisition activities of a single major system. In many cases, those in AFSC 2996 positions "provide executive management supervision" at organizational levels that are administratively higher than those of SPO directors.

The President's Blue Ribbon Commission on Defense Management (the Packard Commission) in its final report, recommended giving "acquisition personnel more authority to do their jobs," reducing the number of layers of supervision, and establishing direct mechanisms for program managers of major programs to report directly to high ranking officials in newly created Program Executive Officer (PEO) positions on program-related matters (16:61,73). This recommendation could be interpreted as a call to increase the autonomy and authority of SPO directors.

## The Acquisition Management Career Development Program

The Acquisition Management Career Development Program (AMCDP) is governed by Air Force Systems Command Regulation (AFSCR) 36-5 (12). While AFSCR 36-5 had not been officially signed and dated at the time this study

was conducted, the AMCDP was experiencing de facto implementation by Air Force Systems Command (AFSC) and the Military Personnel Center (MPC).

The primary focus of the AMCDP is on officers performing duty in the 26XX through 29XX utilization fields. It provides "a phased professional certification process" which "contributes to the motivation of individuals toward career development efforts" and "a formal selection process" intended to "identify those officers best qualified to assume senior acquisition management responsibilities" (12:5).

In the certification process, "specific qualification requirements are identified for academic education, specialty training, professional military education, and acquisition related experience" (12:4). Four sequential certification levels are specified, each associated with fulfillment of a minimum set of requirements in the above-mentioned areas. The academic education requirements for the highest certification level are any Bachelor's Degree and a "Master's Degree (or higher) in a technical or management field appropriate to program management" (12:13). Specialty training applies to courses such as Air Force Institute of Technology (AFIT) SYS 400 (Intermediate Program Management) and the Defense Systems Management College (DSMC) Program Management Course (12:12-13). Squadron Officer School, Intermediate Service School, and Senior

Service School fulfill the professional military education requirements. A mix of SPO, operational, headquarters, and other acquisition-related duties are considered for the experience requirements (12).

The selection process of the AMCDP involves two lists--an Acquisition Managers List (AML), and a Senior Acquisition Managers List (SAML). The AML would establish "a pool of officers who are qualified to fill key middle management positions." The SAML would be comprised of

> . . . officers qualified to assume senior program management positions, including Selected Acquisition Review (SAR) and Air Force Systems Acquisition Review Council (AFSARC) program manager responsibilities.

Each year, a selection board would choose about 100 officers for the AML and 50 officers for the SAML on a "best qualified" basis. For SAML selection, "duty performance, demonstrated leadership ability, and operational experience" would be "weighed heavily." The AML grade requirement would include majors "with enough time-in-grade as to be eligible for secondary zone promotion to lieutenant colonel." SAML officers would need to "be a lieutenant colonel selectee or above" (12:17,19).

The Need for Technical Competence

The reasons technical competence may be desirable in SPO directors are well-documented (2:36; 13:23-24). SPO directors of high-technology programs need some level of technical expertise if they are to effectively evaluate

technical solutions and tradeoffs, assess risks, and weigh technical issues against cost and schedule considerations (19:233-235; 20:36). In addition, technical competence can play an important role in a SPO director's effectiveness in interpersonal relationships (9:16). Without an understanding of the technology at hand, a SPO director may not be able to win the confidence of SPO team members or to build credibility with higher command levels (19:235).

> The problems faced by a project manager with a lack of technical expertise are that he may lose control of a project and cause resentment on the part of participants who feel that he does not understand their position. A lack of technical expertise may also adversely affect the decision-making process. The project manager must either rely on team members for technical decisions or delay the decision until he can consult a third party [9:22-23].

On the other hand, technical competence alone is certainly not sufficient for success in management. A significant degree of management training and aptitude is needed as well (1:39-40). Also, there is some concern that a SPO director who is overly competent technically may concentrate too much on technical details at the expense of other program activities (9:22-23). Indeed, there is a belief that those who are highly skilled technically may not have the "generalist" background desired for senior military management positions (18:8).

Academic education for senior military managers (technical versus liberal arts/humanities degrees) is an area of some debate. A common presumption exists that the

ideal educational background for managers of technical programs is an undergraduate degree in engineering or the physical sciences followed by masters level study in business administration (10:94). This presumption is not unchallenged, though.

According to Dr. William Snyder, current Air Force policy is oriented toward commissioning new officers with technical undergraduate degrees. This is evidenced by the fact that Air Force ROTC scholarships are only awarded to those with engineering and technical majors (18:7-8). While this enables junior officers to make productive contributions in early assignments, he believes that those with more general, nontechnical training will be better suited for executive-level management jobs. To support his point, he cites results of various studies which indicate that those with liberal arts degrees have the advantage in attaining the highest executive levels in business (18:8-12).

Other studies indicate a lack of consensus on the need for SPO directors to have technical backgrounds. Patricia Kelly, a professor at the Defense Systems Management College (DSMC), conducted a survey of government and industry program managers for her article "Searching for Excellence in the Program Office." One of the topics she addressed was the need for military program managers to have technical backgrounds. She reported that twelve

respondents said that a program manager "must be an engineer," must "have a technical background," or must "be technically qualified." There were three people who said a technical background was unnecessary. Interestingly, two of the three respondents who indicated that a technical background was not important were general officers while most of those saying it was important were engineers (13:23-24).

Other factors work to further complicate the question of academic educational background and the underlying importance of technical competence in SPO directors. First, the widely held assumption that a technical degree makes one technically competent may not be valid, especially given the pace at which technology is advancing and the limitations on what is actually covered in any particular engineering curriculum (8). Secondly, the importance of SPO director technical competence may depend on the nature of the program itself. More highly technical programs may call for a higher level of technical competence on the part of the SPO director (2:36; 9:19). Also, there is some evidence that program phase may be a factor to consider. Technical issues may be of greater concern during actual system design and development than in earlier planning or later fielding phases (20:39). Unique characteristics of particular jobs are likely to be factors as well.

## Air Force Program Manager Technical Requirements

For the AFSC 2996 Program Manager Specialty, AFR 36-1 states that "undergraduate academic specialization in engineering, engineering science, engineering management, physical science, or math is mandatory for entry" (7). Requirements for AFSC 2724 and 2716 specialties are the same except that "business/management" specialization is also acceptable (5; 6).

A Master's Degree in a technical field "appropriate to program management" satisfies academic education requirements for the highest certification level of the AMCDP, but a management degree will do so as well (12:13). AFSCR 36-5 does not place any limitations on undergraduate education, but does require two "acquisition-related" specialty courses for certification at the second certification level, some of which are technically oriented (11; 12:11-12).

## Measurement of Technical Competence

This research effort required that ratings of technical competence be obtained for fairly high level program managers. Taking an objective measure of this characteristic would obviously be subject to political and practical pitfalls. One might humorously imagine the plight of a young graduate student seeking approval for and actually attempting to administer some sort of proficiency test to

senior Air Force colonels. A measurement method based on opinions or perceptions has obvious practical advantages (23:4).

First lieutenant Benjamin Wilson conducted a rather extensive review of literature pertaining to "sense of competence" measurement for his Master of Science thesis in 1985. He used a survey instrument developed by Wagner and Morse to measure sense of competence of Air Force junior officers in Civil Engineering (CE) jobs. By tailoring of the wording in the instrument, Wilson obtained ratings from the CE officers and their supervisors on overall sense of job competence, sense of "technical" competence, sense of managerial competence, and job knowledge (23:26-34).

The instrument developed by Wagner and Morse was a 23-item "valid, reliable paper-and-pencil questionnaire." A strong relationship between the sense of competence index measured with this instrument and actual job performance and effectiveness was shown in separate tests conducted with employees from an aerospace company and from county government departments (21; 23:29).

Snyder and Morris conducted research which identified 15 of the 23 Wagner and Morse instrument items that had improved reliability "across different samples and settings" (17; 23:29).

# III. Method

This section describes the methods used to collect and analyze data obtained in support of this research project.

## Justification

A survey approach was chosen for this research primarily because there was no data otherwise found to be available for answering the research questions; data had to be collected. Experimentation was clearly not an option as control of individuals' education and careers would have been required. Objective measurement of technical competence and technical aptitude was deemed to be impractical and inappropriate under the constraints of this effort, as was direct observation by the researcher, leaving survey measurement of perceptions and opinions as the only reasonable data collection alternative. Because of the desire to use technical advisor ratings matched with program manager self-ratings (for purposes of validity), and to avoid potential misunderstanding of the terms and constructs used, personal interviews were chosen over mail surveys (questionnaires) as the preferred survey approach.

## Sample

The population of interest was Air Force officers serving in Air Force Specialty Code (AFSC) 2996 positions (i.e., program managers) and their technical advisors (matched pairs). According to manpower records, there were approximately 275 authorized AFSC 2996 positions in the Air Force at the time of data collection. Of these, approximately 70 were at Wright-Patterson AFB, Ohio. A goal of 55 program manager interviews was set in an attempt to obtain a high level of computationally determined external validity (4:11-14). Due largely to time constraints and scheduling difficulties, a convenience sampling technique was employed. An effort was made to interview as many officers in AFSC 2996 positions at Wright-Patterson AFB and their technical advisors as possible within the constraints.

## Statement of Hypotheses

This study addressed four hypotheses.

1. Ratings of program manager technical competence differ significantly depending upon academic educational background.

2. Ratings of program manager technical competence are significantly correlated (in a positive sense) with ratings of program manager technical aptitude.

3. Ratings of the perceived importance of a program manager having a high level of technical competence differ significantly depending upon the program phase of the system being acquired.

4. A majority (significantly more than 50 percent) of those in program manager positions and their technical advisors feel that technical competence should be part of the criteria used to select officers for key middle management and senior program management positions.

Hypothesis 1. This hypothesis was used to test the relationship between educational background (undergraduate or graduate specialty) and perceived technical competence in program managers. The null hypothesis was that technical competence ratings of program managers would not be significantly different for individuals with different educational backgrounds.

Educational background (the independent variable) was treated as a nominal variable. Specific types of academic degrees were categorized into four different categories based on how closely courses in the various curricula were believed to apply directly to current technical issues likely to be encountered by program managers. The four categories were:

1. Category A--electrical, computer, and aerospace engineering.

2. Category B--other engineering, physical sciences, math and computer science.

3. Category C--business/management and other B.S./M.S. degrees not included in categories A or B.

4. Category D--all other nontechnical (e.g., B.A.) degrees.

The dependent variable was program manager technical competence. Both program manager self-ratings and technical advisor ratings of program manager technical competence were to be obtained. Perceived program manager technical competence was measured using questions from the Wagner and Morse sense of competence instrument (22). Snyder and Morris had identified 15 items from the original 23-item Wagner and Morse instrument which offered consistent reliability loadings "across different samples and settings" (17). Five items from the Snyder and Morris subset were chosen and tailored to apply specifically to technical competence in an acquisition management setting. Ratings from these five items were used to compute a composite variable which constituted the dependent variable (23:30). Responses to each of the five items were rated on a five-point scale. The sum of the five individual ratings was taken as the value of the composite variable which was termed a technical competence index.

Both the program manager and technical advisor survey instruments included the following five items concerning perceptions of the program manager's technical competence:

1. How well the program manager's level of technical competence met expectations for doing his job.

2. How well the technical competence exhibited by the program manager might serve as a role model for an apprentice.

3. To what degree the program manager's talents lay in areas other than in dealing with technical aspects of programs he supervised.

4. How well the program manager had "come up to speed" on technical program issues considering the amount of time in the job.

5. To what degree the program manager had all the technical skills necessary to perform well in his job.

Statistical Testing. Unbalanced single-factor analysis of variance (ANOVA) at a .01 level alpha was used to determine if a significant difference existed in values of the dependent variable between two or more educational categories. The ANOVA F-test indicates whether a significant difference exists between at least two categories, but does not identify where the differences occur. The Bonferroni multicomparison technique was then used to

identify between which categories differences existed. Bonferroni was used because the problem was unbalanced. Since the Bonferroni technique controls Type I error well, but does not control Type II errors as well as other techniques, meaning some significant differences could be masked, a fairly large (e.g., .1) level alpha was used.

The testing was to have been done twice; once using the program manager self-ratings and once using the technical advisor ratings of program manager technical competence.

Hypothesis 2. This hypothesis was used to test the relationship between perceived technical aptitude and technical competence of program managers. The null hypothesis was that there is not a significant positive correlation between ratings of program manager technical aptitude and ratings of program manager technical competence.

Technical aptitude, the independent variable, was a composite interval level variable. For the purpose of this study, the construct of technical aptitude included the following two characteristics:

1. Program manager inquisitiveness on technical program aspects.

2. Program manager quickness in assimilating new technical information.

Both the program manager and technical advisor survey instruments included two items used to measure perceived technical aptitude (one pertaining to each of the above characteristics). Responses to each item were rated on a five-point scale. The sum of the individual ratings was taken as the value of the composite variable termed a technical aptitude index.

The dependent variable was perceived program manager technical competence which was measured as described under Hypothesis 1 above.

Statistical Testing. Correlation analysis was used to calculate a correlation coefficient (Pearson r) for the program manager self-ratings of technical aptitude and technical competence. Correlation analysis of the technical advisor ratings of program manager technical aptitude and technical competence were intended as well. The null hypothesis was that the correlation coefficients would not be significantly greater than zero.

Hypothesis 3. This hypothesis was used to test the relationship between acquisition phase of the program being managed and the importance of the program manager having a high level of technical competence. The null hypothesis was that ratings of the importance of program managers having a high level of technical competence would

not be significantly different for programs in different phases of the acquisition cycle.

Program phase, the independent variable, was treated as a nominal variable. Programs were placed in one of five categories based on the acquisition phase program managers indicated their programs were in at the time of data collection. The five categories were:

1. Category A--Concept Definition
2. Category B--Demonstration and Validation
3. Category C--Full-scale Development
4. Category D--Production and Deployment
5. Category E--Operations Support

The dependent variable, importance of the program manager having a high level of technical competence, was a composite variable treated at the interval level. Two items were included in both the program manager and technical advisor survey instruments for measuring this variable. One item asked for a straightforward rating of the importance of the program manager having a high level of technical competence relative to other factors. The other item questioned whether a lack of technical competence on the part of the program manager was likely to be a serious detriment to the program. Responses to each item were rated on a five-point scale. The sum of the two ratings was taken as the value of the composite variable

which was termed a program manager technical competence importance index.

Statistical Testing. Unbalanced single-factor analysis of variance (ANOVA) at a .05 level alpha was used to determine if a significant difference existed in values of the dependent variable between two or more educational categories. The ANOVA F-test indicates whether a significant difference exists between at least two categories, but does not identify where the differences occur. The Bonferroni multicomparison technique was then used to identify between which categories differences existed. Bonferroni was used because the problem was unbalanced. Since the Bonferroni technique controls Type I error well, but does not control Type II errors as well as other techniques, meaning some significant differences could be masked, a fairly large (e.g., .1) level alpha was used.

The testing was intended to be done twice; once using the program manager self-ratings and once using the technical advisor ratings of importance of program manager technical competence.

Hypothesis 4. This hypothesis was used to test whether more than 50 percent of program managers and technical advisors believed technical competence should be a consideration in selecting officers for high-level program management positions. The null hypothesis was that

significantly more than 50 percent of program managers and their technical advisors do not believe it should be a consideration. Each of the program manager and technical advisor survey instruments included an item which described the AFSCR 36-5 procedure for selecting officers for the Acquisition Managers List (AML) and the Senior Acquisition Managers List (SAML) to assess whether or not each interviewee thought technical competence should also be a consideration in this selection process.

Statistical Testing. A binomial test of proportions was done to determine whether the proportion of "yes" responses was significantly greater than .5 at a .1 level alpha. The test was conducted separately for program manager responses and for technical advisor responses.

## Reliability and Validity

Several actions were taken to promote and assess the reliability and validity of this study.

Sample Size. Generalizability of sample statistics to the population is largely a function of sample and population sizes. A goal of 55 program manager interviews was set so that a 90 percent ± 10 percent confidence level could be achieved for this study as calculated for conducting a test of proportions as in testing on Hypothesis 4. This

sample size was based on a finite population of 275 total AFSC 2996 positions (4:11-14).

Measurement Reliability. Each of the variables which involved ratings of opinions/perceptions (e.g., program manager self-ratings of technical competence) was a composite variable based on at least two survey instrument items. Cronbach alpha reliability coefficients were computed for each of these composite variables as an indication of the measurement reliability of the instruments.

Convergent Validity. Convergent validity is a measure of how well separate instruments measure the same construct or of how similarly separate groups view the same phenomenon. For this research effort, the program manager and technical advisor survey instruments contained the same items (with minor word changes) for measuring opinion/perception variables. Pearson correlation coefficients were computed for program manager versus technical advisor ratings of program manager technical competence, program manager technical aptitude, and perceived importance of the program manager having a high level of technical competence. The strength of these correlations provided an indication of how accurately these constructs were measured. In addition, paired t-tests were conducted to determine if

technical advisor ratings were significantly different than program manager ratings in any of these three rated areas.

## Summary

A convenience sampling technique was employed in collecting data from program managers (those in AFSC 2996 positions) and their technical advisors. The method of data collection was through personal interviews. Statistical analyses were performed in testing four hypotheses which related directly to the research questions that had been posed. Additional statistical analyses were used to indicate the level of measurement reliability of the instruments used and the degree of convergent validity on key constructs.

# IV. Results

## Introduction

A total of 32 interviews were conducted; 26 with program managers and six with technical advisors. Of the 70 AFSC 2996 positions identified within Aeronautical Systems Division (ASD), 13 were vacant and four had security restrictions which prohibited scheduling of interviews. Interviews were not conducted with the remaining 27 program managers due to time constraints and scheduling problems. Technical advisor interviews were particularly difficult to arrange. Some statistical tests proposed in Chapter III using data collected from technical advisors were not warranted due to the low number of technical advisor responses. Those technical advisor interviews that were conducted were used to check for convergent validity with respective program manager responses.

The program managers interviewed were clearly supportive and interested in the topic of this study. Interviews which could have been completed within twenty minutes often lasted over an hour at the interviewee's preference. Much in the way of qualitative perceptions and opinions was recorded in addition to the formal interview responses (14:131-153).

## Tests of Hypotheses

Hypothesis 1. Hypothesis 1 stated that the ratings of program manager technical competence would differ significantly depending upon academic educational background.

Statistical Results. This hypothesis was supported by statistical analysis. The analysis of variance (ANOVA) F test resulted in a p-value of .0015 which was much smaller than the .01 level alpha used in making the test. This indicated a statistically significant difference in ratings of program manager perceived technical competence between at least two of the academic degree categories.

Table 1 shows Bonferroni multicomparison results conducted at a .1 level alpha. This indicates that significant differences in technical competence ratings existed between those in category A (electrical, computer, and aeronautical engineering) and category C (business/ management and other B.S./M.S. degrees not in categories A or B) and between category A and category D (all other nontechnical degrees). No significant difference was indicated between category B (other engineering, physical sciences, math, and computer science) and any of the other categories nor between categories C and D.

Qualitative Findings. Ten of the twenty-six program managers interviewed (38 percent) did not meet

TABLE 1

BONFERRONI MULTICOMPARISON OF PROGRAM MANAGER TECHNICAL COMPETENCE

| Academic Degree Category Comparison | Simultaneous Lower Confidence Limit | Difference Between Means | Simultaneous Upper Confidence Limit |
|---|---|---|---|
| A - B | -3.263 | 2.250 | 7.763 |
| A - D | 0.253 | 6.417 | 12.581*** |
| A - C | 3.066 | 7.607 | 12.149*** |
| B - A | -7.763 | -2.250 | 3.263 |
| B - D | -3.127 | 4.167 | 11.460 |
| B - C | -0.628 | 5.357 | 11.342 |
| D - A | -12.581 | -6.417 | -0.253*** |
| D - B | -11.460 | -4.167 | 3.127 |
| D - C | -5.399 | 1.190 | 7.780 |
| C - A | -12.149 | -7.607 | -3.066*** |
| C - B | -11.342 | -5.357 | 0.628 |
| C - D | -7.780 | -1.190 | 5.399 |

Alpha = 0.1 Confidence = 0.9 DF = 22 MSE = 13.5806

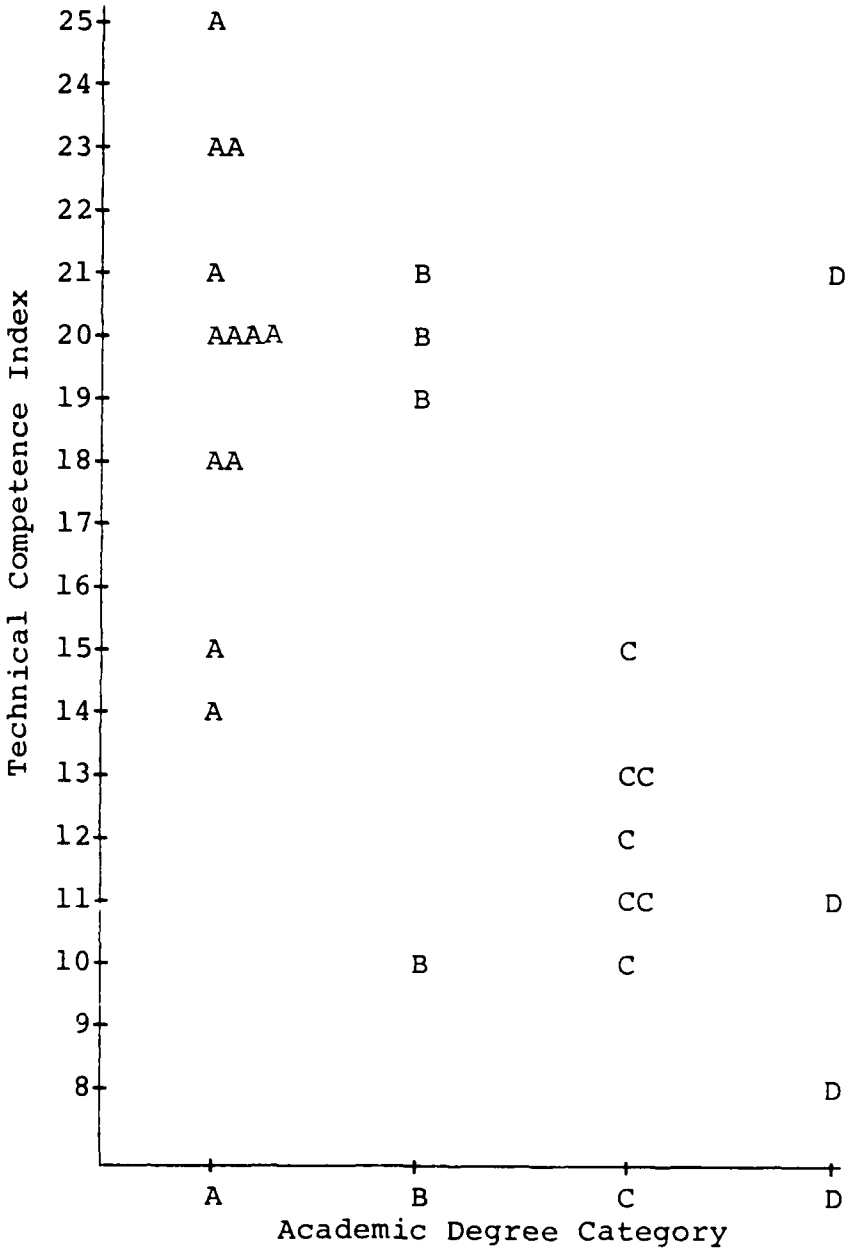
Critical Value of t = 2.59121

NOTE: ***Comparisons significant at the .01 level.

mandatory AFR 36-1 education prerequisites for entry into the AFSC 2996 specialty (7). Figure 1 shows a plot of program manager technical competence ratings for each of the academic educational degree categories. Twelve of the twenty-six program managers interviewed had electrical or aeronautical engineering degrees. None of the officers interviewed had computer engineering or computer science degrees. All of the officers in category C had at least one business or management degree. Again, since this was ex post facto research, these results do not necessarily mean that engineering degrees cause high technical competence. Indeed, some of those in categories A and B did not rate particularly high in technical competence while one category D officer rated very high.

Hypothesis 2. Hypothesis 2 stated that ratings of program manager technical competence would be significantly correlated, in a positive sense, with ratings of program manager technical aptitude.

Statistical Results. This hypothesis was strongly supported by the statistical analysis. A Pearson r correlation coefficient of .86 was obtained indicating a very strong correlation between perceived intrinsic technical aptitude and perceived technical competence.




Legend

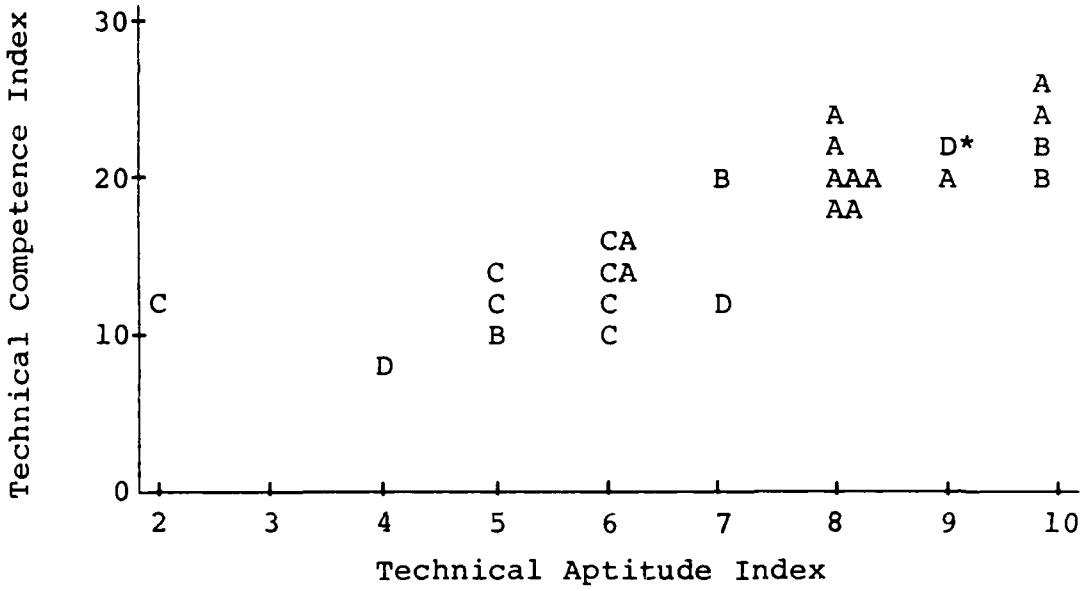
A--Electrical, computer, or aerospace engineering.
B--Other engineering, physical sciences, math or computer science.
C--Business/management and other B.S./M.S. degrees.
D--All other nontechnical (e.g., B.A.) degrees.

Fig. 1. Program Manager Technical Competence versus Academic Degree Category

Qualitative Findings. Figure 2 shows a plot of program manager technical competence indices versus technical aptitude indices. Data points are coded A, B, C, and D according to academic education background. This relationship may serve as an example as to why it is not proper to assume from this study that an engineering education causes high technical competence. Perhaps those with high technical aptitude tend to pursue technical educations. The category D officer with a high technical competence rating (see Figure 1), while possessing only an undergraduate degree in Public Relations, had a very high rating of intrinsic technical aptitude (note the data point marked with an "*" in Figure 2). Again, this research was not structured as an experiment and cannot show causality.

Hypothesis 3. Hypothesis 3 stated that ratings of the perceived importance of a program manager having a high level of technical competence would differ significantly depending upon the program phase of the system being acquired.

Statistical Results. This hypothesis was not supported by statistical analysis. The ANOVA F test resulted in a p-value of .61. This was well above the .05 level alpha established in defining the test. Further




Legend

A--Electrical, computer, or aerospace engineering.

B--Other engineering, physical sciences, math or computer science.

C--Business/management and other B.S./M.S. degrees not included in A or B above.

D--All other nontechnical (e.g., B.A.) degrees.

Fig. 2. Program Manager Technical Competence versus Technical Aptitude

analysis using the Bonferroni multicomparison technique was not warranted.

Qualitative Findings. Research indicating increased levels of management concern in dealing with technical issues during system design and development was not quantitatively substantiated by this study (20). Most of the program managers interviewed were involved primarily with programs in the full-scale development phase. Two program managers focused on programs in the concept definition phase, three on the demonstration/validation phase, three on the production and deployment phase, and one on the operations support phase. Given the small number of observations in each of these categories, this study certainly does not contradict other research in this area (20).

Many of the program managers interviewed indicated that often the technical issues receiving high-level management attention arose during system test, the start of production, or upon initial operational use. However, the consensus was that most truly important, although often obscure, technical considerations having long-term significance were addressed during full-scale development.

Hypothesis 4. Hypothesis 4 stated that a majority of those in program manager positions and their technical

advisors would feel that technical competence should be part of the criteria used to select officers for key middle management and senior program management positions.

Statistical Results. This hypothesis was statistically supported for program manager responses. Seventeen of the 26 program managers interviewed (65 percent) indicated that they felt technical competence should be a consideration in the AFSCR 36-5 selection process. The binomial test of proportions resulted in a p-value of .04 which was less than the .1 level alpha of the test. Due to the small number of technical advisor interviews, this hypothesis was not tested with technical advisor response data.

Qualitative Findings. The question associated with this hypothesis was purposefully intended to solicit program managers' opinions of the AFSCR 36-5 Acquisition Management Career Development Program (AMCDP). The view which seemed to be held by most of those interviewed was that the certification process of the AMCDP would probably have a very positive future effect by encouraging officers in the acquisition business to seek more schooling and a broader range of assignments than might otherwise be the case. The selection process was viewed somewhat less optimistically. A general displeasure with selection based on "square-filling" was expressed.

A recurring theme of the discussions was that an individual's specific, unique set of experiences and capabilities should be considered as a basis for selection to either of the AMCDP lists and especially for job assignments. Program managers seemed to feel strongly that matching individual officer qualifications and strengths with particular job needs had a high payoff.

A typical response to the question associated with Hypothesis 4 was, "Yes, technical competence should definitely be a consideration, but how would it be measured?" Proper evaluation and documentation of technical competence (i.e., measuring the aspects truly important for program management) appeared to be a much warranted concern. Those interviewed invariably noted that added "square-filling" as a means of certifying technical competence would be highly undesirable. Many of those responding negatively to the Hypothesis 4 question said that technical competence was important, but that it would hopefully be factored into the "duty performance" criterion.

## Other Findings

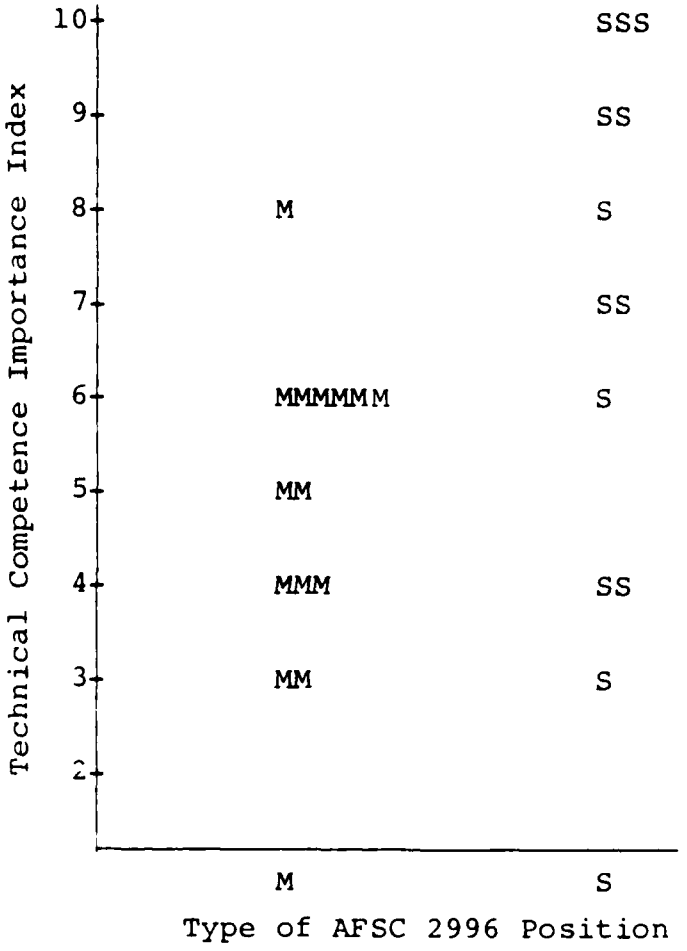
### Importance of SPO Director Technical Competence.

In the very early phases of data collection for this study it became apparent that those officers who functioned as SPO directors placed a much higher priority on the need for technical competence in doing their jobs than did

program managers who provided higher level administrative supervision of multiple programs. The SPO directors often mentioned how technical abilities, in addition to business and interpersonal skills, were needed to interact effectively with the contractor and their own engineers, to make appropriate decisions on trading off cost, schedule, performance, and risk, and to maintain credibility with upper organizational levels. Those in AFSC 2996 positions who were not SPO directors, however, usually described their jobs as strictly business and administration with an emphasis on finance but generally having little to do with technical issues.

Figure 3 shows ratings of the importance of technical competence for SPO directors and for non-SPO director program managers. A t-test comparing the technical competence importance indices of these groups resulted in a p-value of .01 indicating that the difference is indeed statistically significant.

An explanation of what the technical competence importance index scale represents may be in order. This index was based on program manager responses to two instrument questions. Asked to assume they were involved in choosing a successor for their jobs, the first question asked how important a consideration technical competence would be in that selection. The second question asked how serious a detriment it might be if the chosen successor




Legend

M--Multiple Program Oversight

S--Single Program Responsibility

Fig. 3. Importance of High Technical Competence According to Position Type

lacked technical ability but was highly qualified in terms of operational experience and management expertise. A rating of "10" on the Figure 3 index indicates that the program manager responses were that technical competence would be the "most important consideration" and that a lack of technical competence "would definitely seriously hinder the program." An index of "2" would indicate that technical competence was "not a factor at all" and that a lack of technical competence "would not make a difference at all." An index of "6" represents a neutral position. A response that consideration of technical competence would be "even with other factors" and that a lack of technical competence "would be a detriment, but not serious" would be one way of arriving at the neutral index.

Technical Areas for Training/Education Emphasis. In addition to the formal interview questions used for statistical testing and the spontaneous opinions expressed and recorded during the interviews, one completely open-ended question was asked in each interview (14:131-153). The purpose of this question was to identify technical areas warranting increased emphasis in the training and education of SPO director candidates (11). The number of areas mentioned by a single program manager ranged from none to five with most officers naming two areas needing more emphasis.

As Table 2 shows, areas associated with computers, electronics, and basic science and engineering were the most frequently mentioned. While at first glance it may seem surprising that areas like reliability, maintainability, and producibility were mentioned less often, it should be noted that much has been done recently to promote the appreciation of the importance of these disciplines while this question specifically asked for areas warranting increased emphasis.

## Reliability and Convergent Validity

Sample Size. While the actual sample size was smaller than the goal that had been set for this study, it was large enough to obtain slightly better than an 85 percent ± 15 percent confidence level as calculated for the Hypothesis 4 test of proportions (4:11-14).

Measurement Reliability. Cronbach alpha reliability coefficients were calculated for the program manager survey instrument. The reliability coefficients for the five-item technical competence index was .94. A .82 Cronbach alpha was calculated for the two-item technical aptitude index. The two-item technical competence importance index had a .87 Cronbach alpha.

Convergent Validity. For the cases where technical advisor interviews were conducted, Pearson r correlation

TABLE 2

TECHNICAL AREAS NEEDING EMPHASIS

Responses to the question: "What specific technical areas do you believe may warrant increased emphasis in the training and education of officers who will become SPO directors in the future?"

| Area | Times Mentioned |
|---|---|
| Computer Software Development | 14 |
| Basic Electronics | 7 |
| General Engineering or Science | 6 |
| Computer Hardware Technology | 5 |
| Systems Engineering (Integration) | 4 |
| Aerodynamics | 3 |
| Test and Integration | 3 |
| Reliability and Maintainability | 2 |
| Producibility | 2 |
| Avionics | 2 |
| Radar Theory | 1 |
| Materials | 1 |
| Engine Technology | 1 |
| Electronic Combat | 1 |
| Operations Analysis | 1 |
| Inertial Navigation Theory | 1 |

coefficients were calculated to assess the level of program manager and technical advisor convergent validity associated with the three indices. The resulting Pearson r values were .94 for perceived technical competence, .92 for perceived technical aptitude, and .97 for perceived importance of program manager technical competence.

# V. Findings and Recommendations

## Assumptions and Limitations

The primary assumption that must be made in order to generalize the findings of this study to program manager positions outside of Aeronautical Systems Division (ASD) is that the sample used was representative of the population as a whole. While the sample size was smaller than desired (about 10 percent of the population) and was limited to ASD officers, many of those interviewed had worked in other Systems Command product divisions and did not indicate that ASD program management was unique with respect to the questions asked. With regard to the question of technical areas warranting increased emphasis for SPO director candidates, however, one suspects that program managers from other product divisions (Space Division, for example) might provide some additional responses.

An important limitation to recognize is that since this was ex post facto research and not an experiment, this study does not show causality. In particular, it cannot be said that certain types of academic education cause higher levels of technical competence in program managers based upon this research.

Key Findings

The key findings resulting from this research were:

1. Air Force acquisition program managers with Electrical Engineering and Aerospace Engineering academic degrees rate significantly higher in perceived technical competence than do those with liberal arts and business-related degrees.

2. There is a strong correlation between the perceived intrinsic technical aptitude of program managers and their perceived technical competence.

3. A significant number of officers (38 percent of those sampled) in AFSC 2996 positions do not meet mandatory educational prerequisites for entry into the Program Manager specialty per AFR 36-1.

4. The importance of having a high level of technical competence is greater for SPO directors (those functioning as the single manager for developing and delivering a system) than for program managers who provide higher level administrative supervision of multiple programs.

5. Technical competence should be a consideration in the Acquisition Management Career Development Program (AMCDP) selection process, but more investigation may be required to identify a proper method for doing so.

6. Increased emphasis may be warranted in education or training SPO director candidates in the areas of computer hardware and software, basic electronics, and general science and engineering principles. The development and integration of computer software is an area warranting particular emphasis.

Recommendations

The following areas are recommended for consideration and/or action:

1. Recommend the Air Force consider defining two specializations within the 29XX Program Management utilization field; one for officers who function as SPO directors for a single major acquisition program and another for those with supervisory, more administrative program management responsibilities. This change could serve to delineate the different roles and responsibilities of these jobs and might help to clarify reporting relationships to the new Program Executive Officer (PEO) positions.

2. Recommend the Air Force resolve the discrepancy between the AFR 36-1 educational requirements for the AFSC 2996 specialty and the real-world situation. A review of the educational requirements could be accomplished in conjunction with the above recommendation allowing a relaxation of the technical focus for the non-SPO director

specialty. Perhaps a formal waiver process would be in order in the near-term.

3. Recommend those involved in administering the AMCDP selection process and, perhaps more importantly, those involved in assigning selected officers to key program management positions make a serious effort to appropriately consider technical factors when matching individual officers with jobs.

Suggestions for Further Research

The following areas are suggested for further research:

1. The method used in this research effort could be applied to a different, hopefully larger, sample of program managers. One variation might be to attempt to identify differences in technical competence requirements for SPO directors at different Systems Command product divisions. While engineering support at ASD is provided by military and civil service personnel, Space Division and Electronic Systems Division contract for technical support with Federal Contract Research Corporations (i.e., the Aerospace Corporation and MITRE Corporation). Perhaps this difference affects the level to which SPO directors feel the need to personally address technical program issues. Another variation might be to investigate other moderating factors, such as the degree to which a program pushes the state of

the art, that might be associated with the need for a high level of SPO director technical competence.

2. Evaluation of program manager technical competence for selection and assignment purposes is an unresolved issue. An examination of how this might be accomplished practically is in order. A related concern is how to keep SPO directors current in important technical areas given the rapid pace of technological change without an undue overemphasis of things technical. Research could be conducted to identify the suggested content and administration of a program manager technical training effort.

3. The value and purpose of operational experience for acquisition program managers was frequently mentioned in the interviews conducted for this study. Many disparate views were expressed. There was some concern that operational tours might be treated as AMCDP "squares" without sufficient regard for the real benefit derived from a particular operational assignment to a program manager. For example, the value of missile experience to a fighter aircraft program manager was questioned. An exploratory study could be conducted to address the importance of operational experience for acquisition program managers and the associated moderating factors.

## Conclusion

An Air Force officer needs a diversity of knowledge and a variety of talents to excel as an acquisition program manager (2; 7; 12). This study explored one attribute to be considered in prospective program managers; that of technical competence. Extremely capable, versatile, multi-talented officers will be needed to fill SPO director positions in an age of rapidly changing technology, more direct reporting channels, and increased personal authority (16:61,73). Technical competence may not be the single most important quality in future SPO directors, but, in an effort to groom and select the best of the best to manage major system acquisition programs, technical ability must certainly be a serious consideration.

## Appendix A: Program Manager Survey Instrument

1. Educational Degree(s)
   What type of undergraduate degree do you have?
   Any particular area of specialization?
   What post-graduate degrees?

2. Program Phase
   What phase is your program currently in (i.e., Concept Definition, Demonstration/Validation, Full-scale Development, Production and Deployment, or Operations Support)?

3. Self-rated Technical Competence
   In the discussion that follows, the term "technical competence" will be used. The meaning of that term is the ability to assimilate and use technical information. Here, it applies specifically to your ability as a Program Manager to understand technical concepts at a level of detail commensurate with your management position and to properly factor that knowledge into your decision making. The technical competence you have may be due to a variety of factors such as education, experience, or your own intrinsic aptitude. Please keep in mind that the following questions do not deal with how well you do your job as a Program Manager. The focus is on how comfortable you are with your own ability to deal with technical issues.

3.1 How well do you meet your own personal expectations for technical expertise in doing this job?

3.2 Imagine that program managers had apprentices. To what degree would the technical competence you exhibit be a good model for your apprentice?

3.3 To what extent are your talents, or the places you can best concentrate your attention, in areas other than technical aspects of the program?

3.4 Considering the time you have spent in your position, how familiar are you with the key technical aspects of the program?

3.5 Do you feel you have all the technical skills you need to perform well in your job?

4. Self-rated Technical Aptitude

4.1 How strong is your natural tendency to ask questions or solicit information concerning technical aspects of your program?

4.2 How quickly would you say you "come up to speed" as far as understanding technical information that is new to you?

5. Importance of Technical Competence
Assume you got orders to leave this job within sixty days and were involved in choosing your replacement

5.1 How important a consideration do you think it should be that your replacement have a high level of technical competence?

5.2 Suppose the person chosen to replace you had a great deal of operational experience and management expertise but had trouble grasping technical issues. Do you think his lack of technical ability might be a serious detriment to your program?

6. Technical Competence as a Selection Criterion
The new Air Force Systems Command Acquisition Management Career Development Program has provisions for selecting officers to assume senior program management positions on a "best qualified" basis. There is to be an Acquisition Managers List of 100 officers and a Senior Acquisition Managers List of 50 officers selected each year. Duty performance, leadership ability, and operational experience are to be weighted heavily in this selection process. Do you think technical competence should be considered as well?

7. Technical Training/Education Suggestions
What specific technical areas do you believe may warrant increased emphasis in the training and education of officers who will become SPO directors in the future?

Appendix B: Program Manager Data Collection Sheet

Program Manager Name: _____ Rank: ___
Technical Advisor Name: _____

Organization/Program: _____ Category: ___

Category Definitions: M--Multiple program oversight
S--Single program responsibility

1. Educational Degree(s) Category: _____
Undergraduate: _____
Graduate: _____

Category Definitions: A--Electrical, computer, or aerospace engineering.
B--Other engineering, physical sciences, math or computer science.
C--Business/management and other B.S./M.S. degrees not included in A or B above.
D--All other nontechnical (e.g., B.A.) degrees.

2. Program Phase Category: _____

Category Definitions: A--Concept Definition
B--Demonstration/Validation
C--Full-scale Development
D--Production and Deployment
E--Operations Support

3. Self-rated Technical Competence

3.1 Personal Expectations Rating: _____
Rating scale: 1--Not very well
2--Marginally
3--Adequately
4--Fairly well
5--Extremely well

3.2 Model for Apprentice Rating:_____

Rating Scale:
1--Poor model
2--Fair model
3--Acceptable model
4--Pretty good model
5--Exceptional model

3.3 Talents Elsewhere Rating:_____

Rating Scale:
1--Far more talented in other areas
2--More talented in other areas
3--Balanced
4--Technical leaning
5--Most talented in technical aspects

3.4 Familiarity Considering Time Rating:_____

Rating Scale:
1--Not familiar at all
2--Somewhat familiar
3--Familiar with key issues
4--Quite familiar with key issues
5--Intimately/thoroughly familiar with all technical issues

3.5 Technical Skills Rating:_____

Rating Scale:
1--Do not have needed technical skills at all
2--Need more technical skills to perform well
3--Have some technical skills but more would be helpful
4--Have most of needed technical skills
5--Have all of the technical skills needed to perform extremely well

4. Self-rated Technical Aptitude

4.1 Propensity to Question Rating:_____

Rating Scale:
1--Do not seek technical information
2--Occasionally inquire about technical program aspects
3--Question technical matters that become issues
4--Tend to ask questions until comfortable that someone understands
5--Strong tendency to ask questions until technical issues are understood

4.2 Quickness in Learning Rating:_____

Rating Scale: 1--Do not understand technical matters
2--Not a strong point, but eventually understand
3--Average quickness
4--Above average quickness
5--Extremely quick in absorbing technical information

5. Importance of Technical Competence

5.1 Importance Rating:_____

Rating Scale: 1--Not a factor at all
2--Not a very important factor
3--Even with other factors
4--One of the more important factors
5--Most important consideration

5.2 Detriment Potential Rating:_____

Rating Scale: 1--Would not make a difference at all
2--Would be unfortunate, but not seriously harm program
3--Would be a detriment, but not serious
4--Would be likely to hinder the program
5--Would definitely seriously hinder program

6. Selection Criterion Rating:_____

Rating Scale: Y--Should be included
N--Should not be included

7. Training/Education

1._____

2._____

## Appendix C: Technical Advisor Survey Instrument

1. Perceived Program Manager Technical Competence

In the discussion that follows, the term "technical competence" will be used. The meaning of that term is the ability to assimilate and use technical information. It applies specifically to a program manager's ability to understand technical concepts at a level of detail commensurate with his/her management position and to properly factor that knowledge into his/her decision making. Technical competence may be a function of education, experience, and intrinsic aptitude.

1.1 How well does the program manager meet your expectations for technical competence in doing his job?

1.2 Suppose program managers had apprentices. Would the technical competence exhibited by your program manager make a good model for an apprentice to emulate?

1.3 To what extent do you feel the program manager's talents, or where he can concentrate his attention best, are in areas other than technical aspects of the program?

1.4 Considering the time spent in the job, do you feel the program manager is thoroughly familiar with the key technical issues on the program?

1.5 Do you think the program manager has all the technical skills he needs to perform well in his job?

2. Program Manager Technical Aptitude

2.1 How much do you feel the program manager has a natural tendency to ask questions or solicit information concerning technical aspects of the program?

2.2 How quickly does the program manager "come up to speed" as far as understanding technical information that is new to him?

3. Importance of Technical Competence
Assume the program manager got orders to leave within sixty days and that you were involved in choosing his replacement.

3.1 How important a consideration do you think it should be that his replacement have a high level of technical competence?

3.2 Suppose the person chosen to replace him had a great deal of operational experience and management expertise but had trouble grasping technical issues. Do you think his lack of technical ability might be a serious detriment to the program?

4. Technical Competence as a Selection Criterion
The new Air Force Systems Command Acquisition Management Career Development Program has provisions for selecting officers to assume senior program management positions on a "best qualified" basis. There is to be an Acquisition Managers List of 100 officers and a Senior Acquisition Managers List of 50 officers selected each year. Duty performance, leadership ability, and operational experience are to be weighted heavily in this selection process. Do you think technical competence should be considered as well?

5. Technical Training/Education Suggestions
What specific technical areas do you believe may warrant increased emphasis in the training and education of officers who will become SPO directors in the future?

## Appendix D: Technical Advisor Data Collection Sheet

Program Manager Name: _____ Rank: _____
Technical Advisor Name: _____

Organization/Program: _____

1. Program Manager Technical Competence

1.1 Personal Expectations Rating: _____
Rating Scale: 1--Not very well
2--Marginally
3--Adequately
4--Fairly well
5--Extremely well

1.2 Model for Apprentice Rating: _____
Rating Scale: 1--Poor model
2--Fair model
3--Acceptable model
4--Pretty good model
5--Exceptional model

1.3 Talents Elsewhere Rating: _____
Rating Scale: 1--Far more talented in other areas
2--More talented in other areas
3--Balanced
4--Technical leaning
5--Talented primarily in technical areas

1.4 Familiarity Considering Time Rating: _____
Rating Scale: 1--Not familiar at all
2--Somewhat familiar
3--Familiar with key issues
4--Quite familiar with key issues
5--Intimately/thoroughly familiar with all technical issues

1.5 Technical Skills Rating:_____

Rating Scale:
1--Does not have needed technical skills at all
2--Needs more technical skills to perform well
3--Has some technical skills but more would be helpful
4--Has most of the needed technical skills
5--Has all of the technical skills needed to perform extremely well

2. Program Manager Technical Aptitude

2.1 Propensity to Question Rating:_____

Rating Scale:
1--Does not seek technical information
2--Occasionally inquires about technical program aspects
3--Questions technical matters that become issues
4--Tends to ask questions until comfortable that someone understands
5--Strong tendency to ask questions until technical issues are understood

2.2 Quickness in Learning Rating:_____

Rating Scale:
1--Does not understand technical matters
2--Not a strong point, but eventually understands
3--Average quickness
4--Above average quickness
5--Extremely quick in absorbing technical information

3. Importance of Technical Competence

3.1 Importance Rating:_____

Rating Scale:
1--Not a factor at all
2--Not a very important factor
3--Even with other factors
4--One of the more important factors
5--Most important consideration

3.2 Detriment Potential Rating:_____

Rating Scale: 1--Would not make a difference at all
2--Would be unfortunate, but not seriously harm program
3--Would be a detriment, but not serious
4--Would be likely to hinder the program
5--Would definitely seriously hinder program

4. Selection Criterion Rating:_____

Rating Scale: Y--Should be included
N--Should not be included

5. Training/Education

1._____

2._____

## Bibliography


1. Badawy, M. K. "One More Time: How to Motivate Your Engineers," IEEE Transactions on Engineering Management, EM-25: 37-42 (May 1978).

2. Baumgartner, J. Stanley, C. Brown, and P. A. Kelly. "Successful Programs: Can We Learn From Their Experience?" Program Manager, 13: 21-37 (January/February 1986).

3. Department of the Air Force. Acquisition Management: Acquisition Program Management. AFR 800-2. Washington: HQ USAF, 16 September 1985.

4. -----. A Guide for the Development of the Attitude and Opinion Survey, HQ USAF/ACM report. Washington: HQ USAF/ACM, October 1974.

5. -----. Officer Air Force Specialty: Acquisition Management Officer. AFR 36-1, Attachment 10-31/32. Washington: HQ USAF, 1 January 1984.

6. -----. Officer Air Force Specialty: Acquisition Project Officer. AFR 36-1, Attachment 10-33/34. Washington: HQ USAF, 15 March 1985.

7. -----. Officer Air Force Specialty: Program Manager (Systems Program Director). AFR 36-1, Attachment 11-3/4. Washington: HQ USAF, 1 January 1984.

8. Futoran, Maj Carl R. "On the Air Force Officer Corps: Quo Vadis?" Air University Review, 36: 88 (May/June 1985).

9. Gemmill, Gary and David L. Wilemon. "The Power Spectrum in Project Management," Sloan Management Review, 15-25 (Fall 1970).

10. Giegold, William C. "Training Engineers to be Leaders: A Classical Management Approach," IEEE Transactions on Engineering Management, EM-29: 94-103 (August 1982).

11. Headquarters Air Force Systems Command. Air Force Systems Command Career Development Questionnaire. Attachment to HQ AFSC/CV letter. HQ AFSC: Andrews AFB DC, 22 February 1986.

12. -----. Officer Personnel: Acquisition Management Career Development Program. AFSCR 36-5. HQ AFSC: Andrews AFB DC, Undated draft.

13. Kelly, Patricia A. "Searching for Excellence in the Program Office," Program Manager, 13: 20-25 (July/August 1984).

14. Labaw, Patricia J. Advanced Questionnaire Design. Cambridge MA: Abt Books, 1980.

15. "Military R&D: The Worst Shortage is of Trained, Skilled People," Government Executive, 12: 33-34 (May 1980).

16. President's Blue Ribbon Commission on Defense Management (Packard Commission). A Quest for Excellence--Final Report to the President. Washington: Government Printing Office, June 1986.

17. Snyder, Robert A. and James H. Morris. "Reliability of the Factor Structure of the Wagner and Morse Competence Index," Psychological Reports, 43: 419-425 (1978).

18. Snyder, William P. "Educating Military Officers: Specialists Today or Generalists Tomorrow?" Air University Review, 36: 4-13 (May/June 1986).

19. Thamhain, Hans J. "Managing Engineers Effectively," IEEE Transactions on Engineering Management, EM-30: 230-237 (November 1983).

20. Thamhain, Hans J. and David L. Wilemon. "Conflict Management in Project Life Cycles," Sloan Management Review, 16: 31-49 (Spring 1975).

21. Wagner, Francis R. and John J. Morse. "A Measure of Individual Sense of Competence," Psychological Reports, 36: 451-459 (1975).

22. Webster's International Dictionary of the English Language (Second Edition, Unabridged). Springfield MA: Merriam Company, 1955.

23. Wilson, 1st Lt Benjamin R. An Analysis of the Perceived Competence of Junior Civil Engineering Officers. MS thesis, AFIT/GEM/LSB/85S-24. School of Systems and Logistics, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, September 1985 (AD-A160884).

## Vita

Captain Kurt A. Miller was born on 30 May 1956 in Anderson, Indiana. He graduated from high school in Janesville, Wisconsin in 1974, and attended the University of Colorado - Boulder and the University of Wisconsin - Madison, from which he received the degree of Bachelor of Science in Electrical Engineering in December 1978. Upon graduation, he received a commission in the USAF through the ROTC program and entered active duty in January 1979. His first active duty assignment was in the Electronic Systems Division Deputy for Development Plans at Hanscom AFB, Massachusetts where he performed a variety of jobs associated with tactical command, control, communications, and intelligence systems interoperability planning. Then, beginning in October 1982, he served as Reconnaissance Programs Integration Manager in the Aeronautical Systems Division Deputy for Reconnaissance, Strike, and Electronic Warfare at Wright-Patterson AFB, Ohio until entering the School of Systems and Logistics, Air Force Institute of Technology, in June 1986.

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Block 19--Abstract

This study explored how perceived technical competence of Air Force acquisition program managers is related to academic education and intrinsic technical aptitude. Technical competence was defined as the program manager's ability to assimilate technical program information and effectively factor it into his decision making at a level commensurate with his position. This study also attempted to identify situational factors which might increase the importance of a program manager having a high level of technical competence.

Data was collected through personal interviews with officers in AFSC 2996 Program Manager positions and their technical advisors. Key findings were: (1) program manager technical competence is significantly related to educational background; (2) one third of the program managers interviewed do not meet prerequisites for entry into that specialty; (3) SPO direction calls for a higher level of technical competence than other 2996 jobs; and (4) technical ability should be a consideration in the new Acquisition Management Career Development Program selection process.

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